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Researchers discover melanin could make for great batteries

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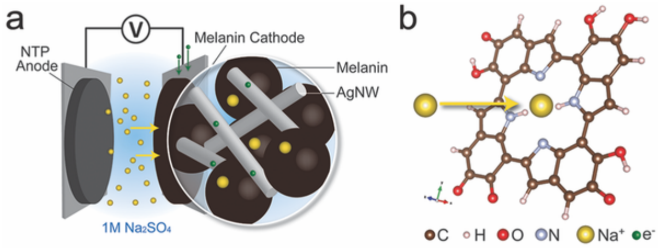

Credit: Carnegie Mellon University Mechanical Engineering

Melanin is best known as the pigment that dictates our skin tones, but it is found just about everywhere—in our brains, in our hair. It is even found in cuttlefish. But as abundant as melanin is, its exact macromolecular chemical structure is surprisingly not well understood.

Though researchers have extensively studied the chemical structure of individual melanin molecules for more than 70 years, relatively little is known about the molecular building blocks that form complex melanin pigments. But a team of researchers from Carnegie Mellon University has discovered that the chemical structure of melanin on a macromolecular scale exhibits, amongst other shapes, a four-membered ring—in other words, a chemical structure that may be conducive to creating certain kinds of batteries based on natural melanin pigments.

"Functionally, different structures of melanin have quite different chemistries, so putting them together is a little like solving a jigsaw puzzle, with each molecule a puzzle piece," explains Assistant Professor of Mechanical Engineering and co-author of the study Venkat Viswanathan. "You could take any number of these pieces and mix and match them, even stack them on top of each other. So the question we tried to answer was, which of these arrangements is the most stable?

There are several possible configurations for melanin with each having a different function depending on its chemical structure. When these molecules bind to form a macromolecular structure, or a polymer, these polymers can be arranged to create a potential battery material. Based on the readings the researchers gained from their experiment, they discovered that a tetramer structure, a four-membered ring composed of larger molecules, appears to be consistent with the structural model of melanin macromolecules.

"Only the tetramer structure had the correct number of exposed nitrogens to bind with the sodium," says Associate Professor of Materials Science and Engineering and Biomedical Engineering Chris Bettinger, "and the voltage signals we received are consistent with what you would observe if you believe that the tetramer is the correct structural model."

The research team—which included Bettinger, materials science engineering postdoctoral researcher Young Jo Kim, and Jay Whitacre, professor of materials science and engineering and of engineering and public policy—was able to discover the tetramer structure of melanin by using it as a battery's cathode. However, in doing so, they also discovered that melanin exhibits a two-voltage plateau characteristic of normal battery materials, while outputting a surprisingly high voltage.

"The voltage we got out was high—comparable to what you would get for the best sodium-based cathode materials we would use in a battery," says Viswanathan. "So this was surprising to us: that we could take this material from biology, and it could function potentially as a very good cathode material."

Read the full article, "Evidence of porphyrin-like structures in natural melanin pigments using electrochemical fingerprinting," in *Advanced Materials*. The research team also included visiting Ph.D. student Abhishek Khetan, Ph.D. student of Materials Science & Engineering Wei Wu, and collaborator Sang-Eun Chun of the University of Oregon.

More information: Young Jo Kim et al. Evidence of Porphyrin-Like Structures in Natural Melanin Pigments Using Electrochemical Fingerprinting, *Advanced Materials* (2016). DOI: 10.1002/adma.201504650

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